

REMARKS

This Response is intended to fully respond to the Office Action dated December 29, 2003. In that Office Action, claims 1-20 were examined. Claims 5-10 and 15-19 were allowed. Claims 1-4, 11-14 and 20 were rejected. More specifically, claims 1-4, 11-14 and 20 were rejected under 35 U.S.C. § 103(a) as being unpatentable over US Patent No. 6,289,360 issued to Kolodner et al., (hereinafter “Kolodner”) in view of “Evaluation of Parallel Copying Garbage Collection on a Shared-Memory Multiprocessor” of Akira Imai and Evan Tick (hereinafter “Imai-Tick”).

For the record, it was noted that the Office Action Summary sheet (item No. 4) incorrectly stated that only claims 1-4, 11-14 and 20 were pending, but it is clear from the rest of the Office Action that all claims were examined and are indeed still pending (e.g., page 2 of the Office Action states that claims 1-20 are pending and that claims 5-10 and 15-19 are allowed).

Reexamination and reconsideration are respectfully requested in light of these remarks. Claims 1-20 are pending in the present application.

Claim Amendments

Applicant respectfully acknowledges the allowance of claims 5 and 15. These claims were amended above to remove a typographical error in which the compacting step inadvertently claimed the act of “updates moves” instead of just “moves”. Thus, the word “updates” was deleted from the claims to clarify that the compacting step moves objects. This amendment is for clarification and does not add new matter. It is further believed that the claims are still in condition for allowance.

Claim Rejections – 35 U.S.C. § 103(a)

Claims 1-4, 11-14 and 20 were rejected under 35 U.S.C. § 103(a) as being unpatentable over US Patent No. 6,289,360 issued to Kolodner et al., (hereinafter “Kolodner”) in view of “Evaluation of Parallel Copying Garbage Collection on a Shared-Memory Multiprocessor,” (hereinafter “Imai-Tick”).

Applicant respectfully traverses the section 103 rejections. The Examiner has failed to substantiate a *prima facie* case of obviousness because one or more of the requirements of a *prima facie* case is absent. Indeed, such a *prima facie* case can only be met when **all** of the following requirements are met: (1) there must be some suggestion or motivation in the references themselves (or in the knowledge available to those skilled in the art) to combine the references; (2) there must be a reasonable expectation of success; and (3) the combined references must teach or suggest all the claim limitations. See MPEP §§ 706.02(j) and 2143. In this case, the combination of Kolodner and Imai-Tick does not teach all of the claim limitations, e.g., the explicit or implicit synchronization of the plurality of processing units during the garbage collection process, i.e., between phases, and there is no motivation to combine the references.

The present invention relates to a method of using multiple processors in its garbage collection process. In using these multiple processors, the memory is divided into separate heaps, and each heap is dedicated to a processor. The separate processors perform several phases of garbage collection on their own dedicated heaps. Importantly, the processors are synchronized because each processor may access objects located in other heaps. Thus, all processors must complete each phase before starting another phase. Furthermore, in order to accommodate multiple processors operating on the multiple heaps of memory, the application process is paused during the garbage collection phase.

In the present Office Action, the Examiner has cited Kolodner as disclosing garbage collection that is performed in phases, such as mark and sweep. Applicants agree that Kolodner describes mark and sweep phases in its particular garbage collection process.

Further however, as in the previous office action, the Examiner has cited Kolodner as disclosing the use of multiple processors, wherein “each processor performs each of the phases on the heap dedicated to the processor using a garbage collection thread executing on the processor (collector threads to force synchronization process: col. 3, lines 25-45 and col. 5, lines 4-14).” Applicant respectfully disagrees with this assertion. Kolodner mentions multiprocessor systems but in fact, describes problems with multiprocessor systems as they apply to concurrent garbage collection systems. This is an important distinction as the “synchronization process” discussed in Kolodner is the coordination of a mutator thread and a collector thread in a **concurrent** garbage collection process which is an entirely different process from the one claimed in the present application.

The mutator thread in Kolodner “is the running program … [that] changes object graphs.” As such, the mutator thread must be synchronized in concurrent garbage collection processes with the collector thread in order to prevent newly allocated memory to be inadvertently treated as unreachable memory. Indeed, Kolodner describes a new method that reduces the dependency on this required coordination between the mutator and the collector threads. Consequently, the only interpretation of Kolodner, as it might apply (assuming *arguendo*) to multiple processors, relates to the synchronization of the mutator thread on one processor and the collector thread on another, unless impermissible hindsight is used.

However, embodiments of the present application do not relate to a concurrent garbage collection process or the synchronization of the mutator thread with anything. The “mutator” of the present invention is paused during the entire garbage collection process. (See Fig. 5). Therefore, the discussion of synchronization in Kolodner does not, in any way, equate to the synchronization of a plurality of processors as described in the present invention. Moreover, since Kolodner does not divide the memory in to heaps (as acknowledged by the Examiner), there is no reason to (a) use separate collector threads or (b) synchronize separate collector threads.

The Examiner further states that Kolodner discloses a process involving “synchronizing the processors so that all processors have completed the preceding phase prior to each processor

beginning the next phase (the beginning phase and the ending phase of the mark-sweep cycle and the synchronization process between the mark-sweep phases: abstract, col. 2, lines 57-67; also col. 3, lines 25-45 and col. 5, lines 44-61).” Applicant also respectfully disagrees with this assertion. As stated above, Kolodner does not describe the synchronization of multiple processors as claimed in the present application. More particularly, Kolodner does not describe the synchronization of multiple collector threads thereby allowing access of any one processor into other, non-dedicated heaps. Since Kolodner does not dedicate heaps of memory to separate processors (or disclose such a possible configuration), **it simply does not disclose the synchronization process claimed in the present application.** Moreover, as stated above, the synchronization described in Kolodner is between the mutator and the collector threads. There is absolutely no discussion of any reason to have multiple collector threads, no discussion of how such an imaginary plurality of collector threads would operate, and clearly no discussion of how or why the collector threads would be synchronized.

Imai-Tick does not satisfy the inadequacies of Kolodner. Imai-Tick describes the use of memory heaps and the balancing of the heaps for management benefits. Moreover, Imai-Tick states that heaps may be dedicated to separate processors to avoid bottlenecks in shared memory access. However, Imai-Tick describes a garbage collection process that does not use mark, sweep and/or compaction steps. Indeed, Imai-Tick uses Baker’s Sequential Algorithm wherein the memory is divided approximately in half, and active objects are identified in the first half of memory and then moved to the second half. Once all active objects are moved from the first half of memory, the entire first half of memory is freed for future use, i.e., garbage objects in the first half are collected upon moving all active objects to the second half of memory. Importantly, this process does not use mark and sweep garbage collection phases, let alone a compaction phase. As a result, there is no need for synchronization between the phases. Although there is a need in Imai-Tick to wait for all garbage collection processes to complete before freeing half the memory, this is not the same as synchronization between phases. As such, the neither Kolodner, Imai-Tick or the combination of references disclose all the elements of the rejected claims, e.g., the synchronization of processors between garbage collection phases.

Furthermore, there is no motivation to combine the references. Indeed, the only apparent language that might be used to combine the references actually teaches away from such a combination. Imai-Tick, at page 1034, column 2, states that in using the Imai-Tick algorithm, the ratio of garbage collection time to total time should decrease as memory increases but since compaction algorithms depend primarily on the size of the memory, the ratio does not change as memory grows. This is interpreted as reason not to combine the teaching of Imai-Tick with other compaction algorithms, e.g., the Kolodner algorithm.

Given that the combined references do not teach or suggest all the claim limitations of the present invention, all claims are believed to be allowable over the prior art. That is, because Kolodner does not disclose multiple heaps, each dedicated to a separate collector thread, or the synchronization of processors between phases, and since Imai-Tick does not teach or disclose, inherently or explicitly the synchronization of processors between phases, claims 1, 11 and 20 are not obvious in light of Kolodner and Imai-Tick. Furthermore, since there is no motivation to combine these references, it is further believed that claims 1, 11 and 20 are also allowable over Kolodner and Imai-Tick for this additional reason. Similarly, all claims depending from those claims are also believed to be allowable and reconsideration of the outstanding rejections in light of these remarks is respectfully requested.

Conclusion

As originally filed, the present application included 20 claims, 6 of which were independent. Claims 5 and 15 have been amended to improve their form and no new claims were added. As amended the present application includes 20 claims 6 of which are independent. It is believed that no further fees are due with this Response. However, the Commissioner is hereby authorized to charge any deficiencies or credit any overpayment with respect to this patent application to deposit account number 13-2725.

In light of the above remarks, it is believed that the application is now in condition for allowance, and such action is respectfully requested. Should any additional issues need to be

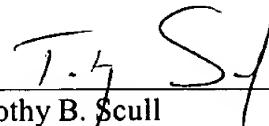
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resolved, the Examiner is requested to telephone the undersigned to attempt to resolve those issues.

Respectfully submitted,

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